Dyselectrolytemia and its outcome in critically ill children- A Prospective study

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ABSTRACT

Objective: The objective of this study is to look for various and common electrolyte imbalances in critically ill children admitted to Paediatric Intensive Care Unit(PICU) and to study the outcome among those cases. **Methods:** This was a prospective observational study done on 84 critically ill children in the age group of 1 month to 12 years admitted in PICU of a tertiary care hospital. Under aseptic conditions venous samples were obtained for estimating serum levels of sodium, potassium, chloride, magnesium and phosphorus. The commonly occurring electrolyte imbalance was observed and the outcome is compared by morbidity, cure and mortality. **Results:** Electrolyte abnormalities were observed in 84 children(100%). Most common electrolyte abnormality observed was hypocalcemia in 70.2% cases (n=59). Morbidity was seen in 35.7% cases (n=30) and mortality associated with dyselectrolytemia was seen in 25.1% cases(n=21). **Conclusion:** This study showed increased incidence of dyselectrolytemia in critically ill children admitted to PICU. But the signs and symptoms are often difficult to recognize an electrolyte imbalance as the imbalances may be primary or secondary to underlying systemic illness. Early recognition and prompt management of electrolyte imbalances can lead to decrease in morbidity and mortality.

Key words: *Dyselectrolytemia, Critically ill, PICU, Mortality, Morbidity*

Electrolytes play an important role in maintaining Homeostasis within the body, regulates myocardial and neurological functions, fluid balance, oxygen delivery and acid-base imbalance. Complex feedback control mechanisms exist to ensure homeostasis or equilibrium and include participation by the kidneys, lungs, gastrointestinal tract, the circulatory system, the endocrine system, and the CNS. Dyselectrolytemia is a common emergent condition in children, may remain unrecognized or may manifest secondary to systemic disorders like Acute Gastroenteritis with dehydration, Diabetic Ketoacidosis, Congestive Cardiac Failure, Bronchopneumonia, Seizure disorder which may result in morbidity and mortality **[1].** Imbalance of electrolytes is a budding condition which can be apparent for other underlying systemic disorders that require admission in the ICU for quick assessment of situations that require active and competent solutions. Hyponatremia occurs in 1.5% of almost all the Paediatric admissions and in 30% of the children treated in ICU and needs to be identified and corrected for the serum sodium level especially in patients with severe acute hyponatremia in order to avert brainstem herniation and death. **[2,3]** severe hypernatremic dehydration leads to shrinkage of the brain. This can lead to bursting of the blood vessels in the cerebrum, and cause cerebral haemorrhage, convulsions, paralysis, and encephalopathy**[4].** Hypernatremia symptoms give's a doughy feeling of the skin of the abdomen when it is pinched. Signs of irritability, sleepiness, hypertonia, coma, fits is associated hypocalcaemia & hyperglycaemia **[5].** Hypernatremia persisting for a prolonged time, and if rapidly corrected and re hydrated with hypotonic fluids, patient may land with cerebral oedema, convulsions, coma and death **[6].Potassium** plays a vital role in normal cell function and is the main

intracellular cation for maintaining homeostasis. Almost all cells have the Na^+- K^+-Atpase pump. [7]. Hypokalaemia is seen to be more likely in malnourished children as they have already a pre-existing potassium depletion. The ECG changes in hypokalaemia are as flattening of T wave, depression of ST segment, and presence of U wave and arrhythmias.[8]

Hyperkalaemia can be a crucial medical emergency and manged with 3 basic goals of quick management. **First** is to stabilize the cell membrane of the myocardial cells to prevent harmful cardiac arrhythmia, **second** to get time form transfer of potassium intracellularly and **third** to increase potassium removal. **Calcium** is a divalent cation which is crucial in maintaining the membrane potential as well as in various other intercellular enzyme processes. Hyocalcemia is also a common problem in critically ill children [9]. **Phosphorus** is one more essential element which is required by our cells for the smooth functioning. It is a vital structural component of cell membranes and nucleic acids. It is involved in many biological processes, such as mineralization of the bones, for energy production, signalling the cells for phosphorylation reactions. It also regulates the acid base homeostasis. [10]

MATERIALS AND METHODS

This prospective observational study was conducted in critically ill children in the age group of 1 month to 12 years admitted in PICU of Dr.DY Patil Medical College, Hospital and Research Centre over a period of 1 $^{1/2}$ years. The study was approved by the Institutional Ethics Committee, and informed written consents were obtained from all the parents.

Children who were receiving prior electrolyte therapy were excluded.

The history and clinical examination of all children was done in detail, as per attached proforma. With all aseptic precautions, blood samples were taken for the detailed investigation along with the initial serum levels of electrolytes like sodium, potassium, chloride, magnesium, calcium, phosphorus were done with in first 48 hours of admission.

The serum electrolytes levels were done by IMT method. All the serum electrolyte levels were compared with the reference values. The clinical and laboratorial assessment of all cases was done by SOFA score, for the severity of illness. Further detailed evaluation and prompt management of all cases was done during their PICU stay. Dyselectrolytemia was managed, with appropriate corrections and repeat serum electrolyte samples were sent. All the children were monitored for the complications and managed accordingly.

Hyponatremia in our study was defined as serum sodium <130mmol/L, hypernatremia as sodium >150 mmol/L, hypokalemia as <3.5mmol/L, hyperkalemia as >5.5mmol/L, hypocalcemia <8.6mg/dl, magnesium and phosphate values according to age.

Statistical Analysis

Statistical Analysis was done by using software IBM SPSS 21 version. Quantitative data was summarized using mean and standard deviation. Qualitative data was summarized using proportions. Appropriate tests of statistical significance such as chi-square test, t test and paired t test were used.

RESULTS

A total of 84 cases were enrolled in this study admitted in PICU aged between 1 month to 12 years. Among those, 45 were males and 39 were females. Majority of the children were in the age group of 9-12 years(n=24). We categorized our cases according to the predominant system involved. Gastro-Intestinal (GI)disorders (n=14) , Diabetic Ketoacidosis(n=11), Surgical intervention (n=9), Respiratory disorders (n=10), Central Nervous System (CNS) disorders (n=9), Cardiovascular disorders (n=9), Multi Organ Dysfunction Syndrome (n=7),

Renal disorders (n=5), Hematological (n=5), others: Poisoning, Metabolic disorders(n=3). Maximum number of cases were of GI disorders followed by Diabetic ketoacidosis (Table 1)

Table 1: Incidence of electrolyte abnormalities

Electrolyte abnormality	Percentage(%)
Hyponatremia	47.6
Hypernatremia	20.2
Hypokalemia	56
Hyperkalemia	13.1
Hypocalcemia	70.2
Hypomagnesemia	8.3
Hypermagnesemia	31
Hypophsophatemia	33.3
Hyperphosphatemia	10.7

Hypocalcemia was the most common electrolyte abnormality, seen in 70.2% cases(n=59)
Hyponatremia was more commonly seen in cases of diabeticketoacidosis(n=10) followed by GI disorders(n=9); Hypernatremia was more observed in CNS cases(n=8); Hypokalemia was more commonly observed in GI disorders(n=14); Hyperkalemia was more common in Renal disorders(n=4) p value of 0.02 which was statistically significant. Severe acute malnourishment and moderate acute malnourishment was seen in 10 cases and 8 cases with hypokalemia; Hypocalcemia was the most commonly observed with GI disorders and Respiratory disorders.
Single electrolyte imbalance was observed in 5 cases of 84 cases. Table 2 describes mixed electrolyte imbalance and the most number of cases were observed to have triple electrolyte imbalance 30.9% (n=26), followed by electrolyte imbalance of 2 electrolytes 29.7% (n=25).

Out of 84 admissions during the stay 57% (n=48) required ventilatory support, 68% (n=57) required ionotropic support, increasing the morbidity among the patients.
SOFA score was assessed in all the admissions and were catregorized into score of 1-6, 7-12, 13-18, and 19-24.(Table 3)

Table 2: Distribution of cases according to mixed dyselectrolytemia

Mixed imbalance	No. Of cases	Percentage(%)
Any 2 electrolyte imbalance	**25**	**29.7**
Any 3 electrolyte imbalance	**26**	**30.9**
Any 4 electrolyte imbalance	**24**	**28.6**
Any 5 electrolyte imbalance	**4**	**4.8**

Table 3: Distribution of cases according to SOFA score

SOFA SCORE	Predictionof mortality	No. of cases=n	Percentage (%)
0-6	Mild (10%)	24	28.6
7-12	Moderate (30-50%)	30	35.7
13-18	Severe (50-90%)	16	19
19-24	Very severe (~90%)	14	16.7

The overall mortality rate was 25.1%(n=21) among children with dyselectrolytemia. The mortality rate was more in children with two or more mixed electrolyte imbalances, and more associated with higher SOFA score.(Table 4)

Table 4: Outcome of cases with dyselectrolytemia

OUTCOME	No. of cases	Percentage(%)
Cured	33	39.2
Co-Morbid	30	35.7
Death	21	25.1

DISCUSSION

Among 84 cases with electrolyte imbalance were enrolled, mixed electrolyte imbalance was present in 94%(n=79) (Table 2), single electrolyte imbalance was seen in 6%(n=5). Most of the previous studies, stated electrolyte imbalance of any two of the electrolytes, studies based on all the electrolyte imbalances are very few.

Study by Agarwal N [11], having 60% of five electrolyte imbalances. Subbarao, et,al [12] stated that incidence was 32% , but focused on two electrolytes. Naseem, F. et.al.[13] stated 84% incidence was found in that study. Cummings BM [10] stated potassium abnormalities alone was 40%. This proves that electrolyte imbalances are common in critically ill children.

In this study, maximum cases were observed in 9 to 12 years of age 28.6% (n=24), and more of male gender 53.6% (n=45), maximum cases observed were in GI disorders 16.6% (n=14), diabetic ketoacidosis 13% (n=11). Among the electrolyte imbalances (Table 1) observed hypocalcemia was the most common 70.2% (n=59). Previous studies mentioned that hypocalcemia in critically ill children was about 57.6% [13], 40% [11], 47.5% [15]. The possible explanation for this is the prevalance of Vitamin D deficiency was more common in Indian Population.[14]

The presence of sodium imbalances was reported to be around 30% [16,17] and hyponatremia is more prevalent than hypernatremia 50.5% vs 9.4% [11],37.6% vs 23.5% [13], 27.4% vs 3.5% [18]; 23.2% vs 16.7% [19]; . However, we found hyponatremia 47.7% and hypernatremia was 20.2% which is similar to the previous studies.

Hypokalemia and hyperkalmeia was observed in 56% (n=47) and 13.1%(n=11) respectively. Previous studies stated incidence of hypokalemia as 40% [10], 34.4%[11], 30.5%[13] and 22.1%[19] and hyperkalemia as 29%[10], 18.8%[13], 16.1%[11], and 11.2%[19]. Hypophosphatemia was observed in 33.3% and hyperphosphatemia in 10.7%, which is smilar to the study by Naseem F, et. Al[13] stated 35.2% of hypophosphatemia and study by Antachopoulos as 37.5% [20.] Incidence increases to 61% in critically ill children according to study by ME Santana[21].

In our study, incidence of hypermagnesemia was more than hypomagnesemia as 31% vs 8.3% (Table 1), which is similar to the study by Naseem, F. et. al as 21% vs 7%.[13]

Morbidity was significant in cases with mixed electrolyte imbalance. Mortality was seen in 25%(n=21) cases and all the cases had mixed electrolyte imabalance which is similar to study by Naseem, F. et. al 27%.[13]

Table 5 describes the comparision of similar studies.

CONCLUSION

Electrolytes play an important role in maintaining homeostasis. Dyselectrolytemia is a common emergent condition in critically ill children which may remain unrecognized or manifests secondary to systemic disorders which may result in morbidity and mortality.

Early detection and prompt management of dyselectrolytemia can decrease morbidity and mortality.

Table 5: Comparision of our study with the other studies

Characteristics	Our study	Naseem, F, et. al.	Routray,M.et.al	Chary, et. al
No. Of cases	84	101	340	132
Male	45(53.6%)	61(60.39%)	224	68(51.5%)
Female	39(46.4%)	40(39.6%)	116	64(48.4%)
Hyponatremia	47.6%	23.5%	10.59%	40.8%
Hypernatremia	20.2%	37.6%	4.7%	12.6%
Hypokalemia	56%	30.5%	3.82%	11.2%
Hyperkalemia	13.1%	18.8%	16.18%	18.3%
Hypocalcemia	62.7%	57.6%	2.62%	
Hypomagnesemia	8.3%	7%		
Hypermagnesemia	31%	21.1%		
Hypophosphatemia	33.3%	35.1%		
Hyperphosphatemia	10.7%	11.7%		
Most common observed imbalance	Hypocalcemia	Hypocalcemia		
Outcome (mortality)	25.1%	22.7%		

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